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Paleo nitrogen-cycle shifts may shed light on current oceanic changes

As Earth started warming after the peak of the last ice age, 18,000 years ago, the ocean's nitrogen cycle began speeding up, eventually stabilizing 10,000 years later at a faster rate, say an international team of forty researchers in the journal Nature Geoscience.

The result confirms the ocean is an effective self-regulator with respect to nitrogen, a major nutrient, but reaching equilibrium after a disturbance can take hundreds or thousands of years, a concern given the scale and speed of current anthropogenic change.

According to lead author Eric Galbraith from McGill University, in Montreal, Canada "We were looking at how the ocean dealt with the slow, natural climate warming that took place over several thousands of years as the world emerged from the last ice age, leading up to the dawn of civilization."

Humans are currently adding nitrogen to the ocean from excess agricultural fertilizer, and fossil fuels are warming the ocean. Both are putting pressure on the ocean nitrogen cycle.

"But despite its importance for all marine life, we don't really have a good handle on how the global ocean will react to these changes," said Galbraith.

In some ways, the global ocean is like one big self-regulating organism. One of its critical jobs is to maintain a balance between the amount of nitrogen it contains, fertilizing phytoplankton growth, and the amount of dissolved oxygen.

"With too little nitrogen, the ecosystem would starve. Too much, and the decay of sinking phytoplankton would use up the oxygen dissolved in ocean water, suffocating fish and other marine animals," explained Galbraith.

The balance is maintained by marine bacteria, through 'fixation', which supplies nitrogen in the shallow, sunlit waters, and 'denitrification', which eliminates nitrogen in dark, oxygen-poor pockets.

Together, this comprises the nitrogen cycle.

After they die, some of the nitrogen-rich phytoplankton (floating algae) sink and collect in the mud at the seafloor. Over thousands of years, this slow accumulation builds up a vertical record of past changes that can be sampled by taking a sediment core.

Previous studies of the isotopes of nitrogen in these sediment records had shown signs of changes in denitrification at the end of the ice age, in some localized places. But the nitrogen isotope records are difficult to interpret from individual sites alone.

“Our new work brought together an international team to assemble a global network of sediment cores to see the full picture clearly, and to compare the results with computer models of the ocean,” said co-author Markus Kienast of Dalhousie University in Halifax, Canda, the study’s second lead author.

The new global view shows that denitrification picked up rapidly as the ice sheets started melting and climate warmed - the dark pockets of the ocean becoming more oxygen-poor, as might be expected, since warmer water holds less dissolved oxygen.

This would have had consequences for ecosystems, which would have had to adapt to the gradually diminishing supply of nutrients and oxygen.

But by the time the largest ice sheets were gone and agriculture started taking off, the nitrogen fixation had sped up and compensated for the loss of nitrogen from denitrification. The ocean had eventually stabilized itself in its new, warmer state, in which the overall nitrogen cycle was running faster.

“Our results suggest that the self-regulating ocean is good at balancing the nitrogen cycle on the global scale, but that achieving the new balance probably takes many centuries, if not millennia.”

How the ocean will deal with the rapid human-caused climate change currently underway, and how dramatically local ecosystems will be forced to adapt, remain open questions, say the researchers.

The work is a result of a working group of the Past Global Changes (PAGES) project that specifically focuses on the Nitrogen Cycle, Past and Present (NICOPP).

Reference

"The acceleration of oceanic denitrification during deglacial warming"
Galbraith E.D., Kienast M. and NICOPP working group members
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